CHAPTER 7
DEMAND FOR REMEDIATION OF DEPARTMENT OF ENERGY SITES

One of the most serious and costly environmental remediation tasks facing the federal government is the cleanup and restoration of more than 100 major installations and other locations that are the responsibility of the U.S. Department of Energy (DOE). Environmental problems at DOE installations stem from activities that began in the 1940s with the Manhattan Project and continued throughout the Cold War. In the 50 years since the Manhattan Project, the United States has spent more than $300 billion (in 1996 dollars) on nuclear weapons research, production, and testing—manufacturing tens of thousands of nuclear warheads and detonating more than 1,000.[1]

The environmental problems associated with DOE properties, unlike those of other industries, include unique radiation hazards, unprecedented volumes of contaminated soil and water, and a large number of contaminated structures ranging from nuclear reactors to chemical plants for the extraction of nuclear materials to evaporation ponds.[1] DOE estimates that environmental restoration, the cleanup of its hazardous waste sites, will cost $63 billion and take about 75 years.[2][3] Environmental restoration accounts for 28 percent of the $227 billion life-cycle-cost DOE has estimated for all environmental management activities at its facilities. The other 72% of DOE's environmental management costs are for the following types of activities: waste management, nuclear material and facility stabilization, national program planning and management, landlord activities, and technology development. DOE's environmental cleanup program offers an enormous opportunity for firms that provide remediation services.

Although DOE has come a long way, particularly over the last two years, in defining the scope of the remediation needed for many of the 10,500 "sites" the agency has identified to date, most of them still are being evaluated.[2] Throughout this chapter the term "site" will be used to indicate an individual area of contamination. In June 1996, the agency issued its most comprehensive report to date on the status and potential cost of cleaning up the backlog of accumulated problems, as well as the wastes to be generated from ongoing national security operations and from the cleanup efforts themselves. The report, *The 1996 Baseline Environmental Report,* which will be updated and reissued periodically, summarizes environmental management activities—including environmental restoration (cleanup), waste management, nuclear material and facility stabilization, technology development, and landlord responsibilities—and provides tentative schedules and estimates of the life-cycle costs involved in completing the agency's Environmental Management program (See Sections 7.3 and 7.4 for additional information).

7.1 Program Description

DOE's environmental programs are managed by its Office of Environmental Restoration and Waste Management (EM) through six major program offices: Office of Waste Management, Office of Management and Finance, Office of Nuclear Material and Facilities Stabilization, Office of Site Operations, Office of Science and Technology, and Office of Environmental Restoration.[4] As its name implies, the *Office of Waste Management* is concerned with the treatment, storage, and disposal of wastes generated from DOE's ongoing operations. The Office of Waste Management also is responsible for DOE's waste minimization effort and for corrective activities at the agency's waste management facilities. These programs are intended to bring all DOE waste management facilities into compliance with applicable federal, state, and local regulations related to health, safety, and the environment.

In addition to overall EM administrative and budget functions, the *Office of Management and*

Finance conducts cost and performance analyses related to the agency's environmental management programs. The *Office of Nuclear Materials and Facilities Stabilization* implements DOE's efforts to deactivate and properly maintain closed facilities until they can be decontaminated and decommissioned or released for other uses. The *Office of Site Operations* is responsible primarily for programs related to integrating good risk management practices and credible risk assessment procedures into the environmental management decision-making process, increasing public understanding of and involvement in environmental decision-making, and developing the agency's environmental justice public participation strategy.

The *Office of Science and Technology* is responsible for developing technologies to meet DOE's goals for environmental restoration and waste management. Its activities include research and development; demonstration, testing, and evaluation; technology integration; and technology transfer.

The *Office of Environmental Restoration* is the primary focus of this chapter. The Office of Environmental Restoration is responsible for all activities to assess and clean up inactive hazardous and radioactive "facilities"—such as reactors, laboratories, equipment, buildings, pipelines, waste treatment systems, and storage tanks—and sites at all DOE installations and at some non-DOE locations that have been specified by Congress. This program includes cleanup activities at 25 DOE installations and other locations listed on the National Priorities List (NPL); corrective actions under the Resource Conservation and Recovery Act (RCRA), which are necessary for sites at about one-quarter of DOE's installations; and cleanup required under other environmental programs.[5] [6]

Environmental Restoration activities include:

- **Decontamination and decommissioning (D&D)**—decontamination and safe disposition of deactivated and surplus equipment, buildings, and other facilities;

- **Remedial actions**—site characterization to identify the contaminants and physical properties at a site, and remediation actions to stabilize, reduce, or remove contaminants at a site; and

- **Long-term surveillance and maintenance (S&M)**—monitoring the site to ensure that contamination has been successfully addressed and providing maintenance services to ensure the long-term integrity of containment remedies or continued effective operation of pump-and-treat remedies.[5]

These three activities are described in the following subsections.

7.1.1 Decontamination and Decommissioning (D&D)

Decontamination and Decommissioning (D&D) is DOE's program to manage government-owned, surplus, deactivated "facilities" that were used for early nuclear energy research and defense programs. These "facilities" could include reactors, hot cells, processing plants, storage tanks, research facilities, and other structures where releases or spills have occurred. DOE is responsible for decontaminating and safely disposing of these surplus facilities. Disposal could include demolishing the building and removing rubble from the facility, collapsing the facility to a below-ground level and burying rubble under a protective cap, or converting a completely decontaminated facility for non-nuclear use. D&D operations are ongoing or planned at just over 30 DOE installations and other locations. Overall, the program is addressing about 5,000 contaminated buildings that require deactivation, 1,200 buildings that require decommissioning, and 550,000 metric tons of metals and 23 million cubic meters of concrete in buildings that require disposition. [2][5]

7.1.2 Remedial Actions

Remedial action at sites throughout the DOE complex involves treatment, disposal, and, in some cases, transfer to the Waste Management Program of a variety of wastes. These wastes are categorized as:

- hazardous—containing hazardous constituents but no radionuclides;

- mixed—containing both hazardous and radioactive materials;
- low-level—containing a small amount of radioactivity in large volumes of material;
- 11e(2) byproduct material—containing very low concentrations of naturally occurring alpha-emitting radionuclides in large volumes of generally soil-like materials;
- transuranic—containing plutonium, americium, and other elements with atomic numbers higher than uranium; and
- high-level—containing highly radioactive material—including fission products, traces of uranium and plutonium, and other transuranic elements—resulting from chemical reprocessing of spent fuel.[1] [2]

DOE expects to remediate almost 3.8 million cubic meters of the hazardous waste, and nearly 5.7 million cubic meters of mixed waste, at its installations and other locations over the life of the program.[7] DOE's Environmental Restoration Program addresses waste through remediation (including *in situ* and *ex situ* treatment and disposal) or, in some cases, through transfer of the waste to the agency's ongoing Waste Management Program.

Most of DOE's installations require remedial action under one or more environmental statutes. These installations vary widely in size. For example, the Laboratory for Energy-Related Health Research in Davis, California, occupies 15 acres, while Hanford Reservation in the southeastern part of Washington covers 560 square miles. Overall, DOE installations encompass 2.3 million acres of land.[3]

Characterization and assessment (C/A) activities are in progress at most installations and other locations. Much of this work will continue for years, and complete remediation will take longer still. However, by the end of 1995, DOE had completed 198 remedial actions (including cleanup at a variety of operable units [OUs], closures, etc.) and over 100 others were underway.[5] In addition, DOE continues to implement, as needed, interim actions (limited actions to mitigate risks from contamination) as the process of characterization, assessment, and cleanup moves forward at its installations.[2][3]

More than half of the installations and other locations in DOE's Environmental Restoration program are managed under the Formerly Utilized Sites Remedial Action Program (FUSRAP) and the Uranium Mill Tailings Remedial Action (UMTRA) Project. FUSRAP involves the cleanup or control of 46 locations—some owned or leased by DOE or other government agencies, some privately owned—where there is residual radioactive material from the early years of the Nation's atomic energy program. By the end of 1995, cleanup at 22 of these installations had been completed, and cleanup work currently is in progress at nine of the 24 remaining installations to be remediated under the program. DOE anticipates that remediation activities under FUSRAP will continue through 2016.[2][5][7]

UMTRA provides for stabilizing and controlling surface contamination from 39 million cubic yards of uranium mill tailings at 24 former uranium ore processing sites and for addressing groundwater contamination beneath and, in some cases, downgradient of the mills.[5] The tailings resulted from the production of uranium between the early 1950s and the early 1970s. In addition to the 24 processing sites, mill tailings remediation also has been completed at over 97 percent of the over 5,000 private residential and commercial properties, under the UMTRA project. These "vicinity" properties are contaminated because tailings were used as fill for construction and landscaping, or were carried by the wind to open areas. By the end of 1996, DOE had completed surface remediation at 18 processing sites and their associated vicinity properties; and remediation was ongoing at six others. Surface remediation is expected to be completed by the end of 1998.[5]

DOE currently estimates that about 4.7 billion gallons of groundwater at 23 of the ore processing sites being addressed under UMTRA are contaminated. The Lowman, Idaho, UMTRA location is the only one which shows no sign of groundwater contamination. Restoration of groundwater has yet to begin at UMTRA locations. DOE published a draft programmatic environmental impact statement for this portion of the program in April 1995.[8] Site-specific remedial action plans for the UMTRA groundwater projects are expected to be prepared beginning in 1997 and continuing through 2007. DOE anticipates that active remediation of these locations will begin as early as 2002 and be completed by 2014.[5]

7.1.3 Long-term Surveillance and Maintenance

Long-term surveillance and maintenance activities are integral to the environmental restoration process. In decontamination and decommissioning projects, DOE's S&M activities include monitoring and maintaining facilities awaiting D&D to prevent worker, public, and environmental exposure to potential hazards. The agency conducts post-S&M activities when remediation projects have been completed. These include monitoring sites to demonstrate that actions to contain, reduce, or stabilize contamination are effective over time; to ensure that any new problems are detected if they occur; and to provide ongoing maintenance—for example, at sites where containment remedies, such as capping or entombment, have been implemented and at groundwater sites where the remedy involves long-term pump-and-treat operations.[2]

7.2 Factors Affecting Demand for Cleanup

The following factors affect the demand for remediation of DOE installations.

- Cleanup and restoration work at most DOE installations is in the early stages. The nature and magnitude of the contamination at many sites are still only partially known; only about 46 percent of the more than 10,500 sites have been fully characterized.[2]

- Although DOE estimates that it will take 75 years (1996 to 2070) to complete the cleanup, it expects to remediate nearly 80 percent of its currently known sites by 2021. Thus, the next about 25 years is a "window of opportunity" for vendors of remediation technologies and services. An indication of the scheduling of he work is provided by a review of the milestones in Records of Decision (RODs) for NPL-listed DOE sites. RODs for 32 hazardous waste OUs at DOE NPL sites were expected to be completed in 1996. RODs for another 104 hazardous waste OUs, about 50 percent of the remaining ones for which a completion milestone is known, are expected to be completed by 2000 (Exhibit 7-1). These figures refer to operable units as defined under the Comprehensive Environmental Response, Compensation, Liability Act (CERCLA)). DOE uses a different definition for its OUs. DOE expects to complete cleanup of all sites and bring all its installations into environmental compliance by 2070.[2]

- In developing its 75-year estimate of the time required for cleanup of all installations, DOE assumed a greater emphasis on containment than on treatment and other active remediation strategies.[2]

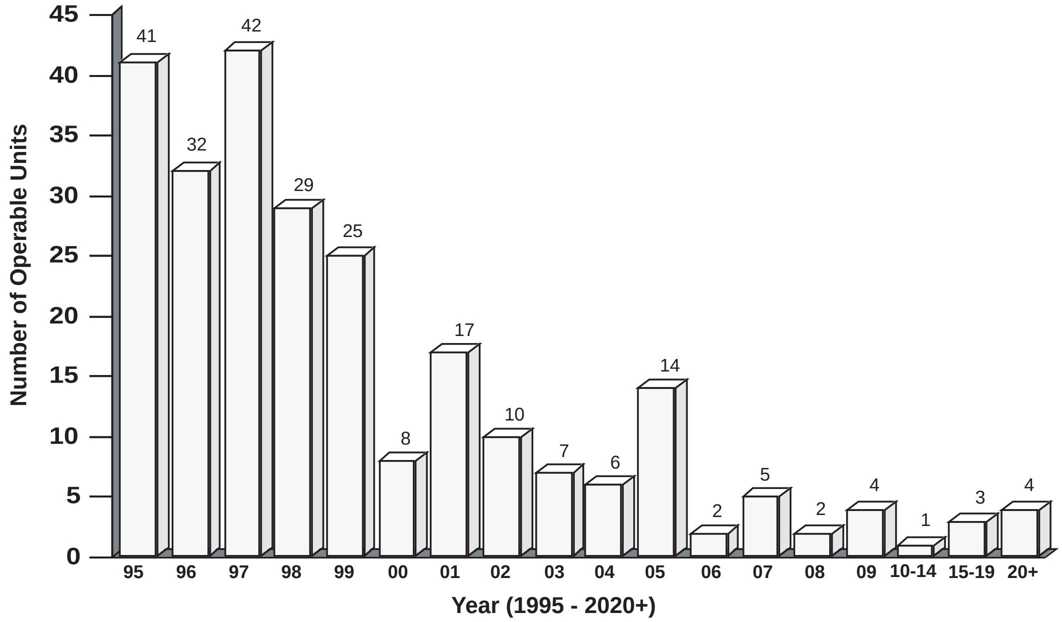
- The 75-year estimate to remediate all DOE installations could be lengthened or shortened depending on the funds appropriated by Congress for DOE programs. Cleanup schedules are heavily dependent on available funds. DOE officials have indicated from time-to-time that proposals for significant reductions in the agency's future budgets likely would delay cleanups at some installations and, in some cases, interfere with the agency's ability to meet milestones in existing compliance agreements.[9]

- DOE gives top priority to cleanup activities necessary to prevent near-term adverse impacts to workers, the public, or the environment and to activities required to meet the terms of agreements between DOE and local, state, or federal agencies.[2]

- The type and extent of remediation required will be affected significantly by the level of residual contamination after cleanup that will be acceptable to regulators and the public. The acceptable residual contamination level is unknown for most DOE installations, since cleanup agreements for many installations have not been completed.[2]

- Acceptable cleanup levels and the type of remediation required also will be influenced by decisions concerning how land and facilities are expected to be used in the future. The process of making decisions on these

Exhibit 7-1: Estimated ROD Completion Dates for CERCLA Operable Units at DOE Installations and Other Locations



Notes: Includes 252 CERCLA operable units for which a completion milestone is known at all DOE installations and other locations that the Environmental Restoration Program is responsible for remediating through its various programs, including Decontamination and Decommissioning, FUSRAP, and UMTRA. An "operable unit" consists of one or more "sites" (individual areas of contamination).

Source: U.S. Department of Energy, *Environmental Restoration Program at a Glance*, March 1995 (Rev. 1.0).

matters still is underway for most DOE installations and facilities.[2]

- As with DOD, cleanup requirements at DOE installations and other locations are extremely sensitive to changes in a wide variety of environmental statutes and regulations. Remedial, decontamination, decommissioning, and waste management and compliance-related corrective activities overlap at many installations. The requirements of a variety of federal and state laws simultaneously impact decision-making. In addition to CERCLA and RCRA, other relevant statutes include the Atomic Energy Act, the National Environmental Policy Act (NEPA), and the Federal Facility Compliance Act. Vendors in this market should keep up to date on regulatory and legislative developments of concern to DOE remediation efforts.

7.3 Number and Characteristics of Sites

DOE is responsible for environmental restoration at 137 installations and other locations in 33 states and Puerto Rico. Many installations contain more than one site. Depending on the size and complexity of the installation, sites may be aggregated into one or more OUs and each OU may require a different remedy. DOE has identified about 10,500 contaminated sites that require some remediation, and that number may grow as assessment and characterization activities continue. The contaminated sites that have been identified to date have been aggregated into over 700 OUs. DOE periodically increases or decreases the number of OUs, as a result of continual reevaluations of the designation of OUs as the program progresses.

Twenty-five DOE installations and other locations in 15 states are on the Superfund National Priorities List (NPL). In some cases, the Superfund cleanup may involve only one operable unit at the installation; in others multiple operable units may be affected. DOE has lead responsibility in the cleanup of 22 of these installations and other locations. The other three—Maxey Flats, Kentucky; Shpack Landfill, Massachusetts; and South Valley, New

Mexico—are being managed under the Superfund program by EPA, and DOE shares financial responsibility for the cleanup with other responsible parties.[2][5]

Exhibit 7-2 lists 86 installations and other DOE locations at which assessment and characterization of soil, groundwater, or both are in progress or have yet to be initiated for some or all operable units.[2] These installations represent the potential market for hazardous waste remediation services. The list includes 20 of the 25 DOE installations and other locations on the NPL. Appendix Exhibit D-1 provides similar information for DOE installations, including the other five on the NPL, where remedial work already is in progress or has been completed and, thus, does not represent many vendor opportunities.[2][3]

Some installations are listed in both Exhibit 7-2 and Appendix Exhibit D-1. While remedial action may be ongoing at some operable units at these installations, they continue to represent opportunities for vendors because other operable units still are being characterized and assessed.

DOE estimates that 64 percent of the total estimated cost of environmental management activities over the 75-year life of the program will be expended at five major installations—Rocky Flats Environmental Technology Site (Colorado), Idaho National Engineering Laboratory (Idaho), Savannah River Site (South Carolina), Oak Ridge Reservation (Tennessee), and Hanford Reservation (Washington).[2] These installations contain 406 operable units, more than half of the operable units DOE is responsible for addressing. Points of contact for each of these installations are listed in Appendix E.

Information about the extent of contamination at many of the installations listed still is incomplete. DOE has made substantial progress, however, in identifying specific contaminants of concern for many individual sites. Exhibit 7-3 shows the frequency with which major contaminants and categories of contaminants have been identified at the DOE installations and other locations where characterization and assessment (C/A) has not been completed. This Exhibit is derived from Appendix Exhibit D-2, which shows the contaminants of concern, to the extent they are known, at each of the 86 DOE installation and other locations where C/A has not been completed. These data were compiled from four sources: March 3, 1995 tabulations from the DOE/EM-40 Contaminated Media/Waste Database; DOE's *Estimating the Cold War Mortgage: The 1995 Baseline Environmental Report*, published in March 1995; DOE's *1996 Baseline Environmental Report*, published in June 1996, and the agency's *Draft Programmatic Environmental Impact Statement for the Uranium Mill Tailings Remedial Action Ground Water Project*, published in April 1995. The contaminant information in these sources indicate only that a contaminant has been identified at an installation. The data do not indicate if specific contaminants have been identified at only one site or at more than one site at the installation.

Organics are among contaminants at about 38 percent of the DOE installations that have not begun remediation. Among these are polychlorinated biphenyls (PCBs), petroleum/fuel hydrocarbons, solvents, trichloroethylene (TCE), "unspecified" volatile organic compounds (VOCs), and "unspecified" semivolatile organic compounds (SVOCs).

Metals are listed as contaminants of concern at 55 percent of DOE installations yet to start remediation. Those cited most often are lead, beryllium, mercury, arsenic, and chromium.

Radioactive contaminants are present at most DOE installations and other locations. The most frequently cited are uranium, tritium, thorium, and plutonium.

Mixed waste, containing both radioactive and hazardous contaminants, is a particular concern to DOE because of the lack of acceptable treatment technology and the high cost and scarcity of disposal facilities. Mixed waste is the focus of one of DOE's major technology development thrusts (see Section 7.6).

Exhibit 7-2: DOE Installations and Other Locations Where Waste Characterization and Assessment Are Ongoing

State	Installation/Site	Program[2]	Status[3]	No. of Operable Units[3,4]	Estimated Budget FY 1997 (millions)[3]	Estimated Life-Cycle Cost (millions)[3]
AK	Amchitka Island	ER	Not Initiated	1	$0.22[5]	$6.3[5]
AZ	Monument Valley	ER/UMTRA	C/A ongoing (ground water)	1	$1.0	$112.6
	Tuba City	ER/UMTRA	C/A ongoing (ground water)	1	$3.56	$99.2
CA	Energy Technology Engineering Center	ER (including D&D)	C/A ongoing	16	$4.21	$131.0
	General Atomics	ER (including D&D)	C/A, D&D ongoing	1	$3.6	$17.0
	General Electric/Vallecitos Nuclear Center	ER (including D&D)	C/A ongoing	2	$0	$23.3
	Geothermal Test Facility	ER	Not Initiated	1	$0	$5.1
	Laboratory for Energy-Related Health Research	ER (including D&D) on NPL	C/A, D&D ongoing	9	$3.55	$21.1
	Lawrence Berkeley Laboratory	ER	C/A ongoing	4	$3.19	$54.4
	Lawrence Livermore Laboratory	ER (including D&D) on NPL (2 sites)	C/A ongoing	11	$22.51	$639
	Oxnard	ER	Complete	1	$0	$0.5
	Salton Sea Test Base	ER	C/A ongoing	Included in data for Sandia National Laboratory-Albuquerque through which this site is managed.		
	Stanford Linear Accelerator Center	ER	C/A ongoing IA in progress	1	$1	$5.0

Exhibit 7-2: DOE Locations Where Characterization and Assessment Are Ongoing (continued) [1]

State	Installation/Site	Program[2]	Status[3]	No. of Operable Units[3,4]	Estimated Budget FY 1997 (millions)[3]	Estimated Life-Cycle Cost (millions)[3]
CO	Durango Site	ER/UMTRA	C/A ongoing (ground water)	1	$0.02	$12.1
	Grand Junction Mill Tailing Site	ER/UMTRA	C/A ongoing (ground water)	1	$12.8	$73.3
	Gunnison	ER/UMTRA	C/A ongoing (ground water)	1	$0.9	$12.3
	Maybell	ER/UMTRA	C/A ongoing (ground water)	1	$4.3	$22.3
	Naturita	ER/UMTRA	C/A ongoing (ground water)	1	$12.35	$43
	Old North Continent (Slick Rock)	ER/UMTRA	C/A ongoing (ground water)	1	$9.1	$32.9
	Project Rio Blanco	ER	C/A ongoing	1	$0.7[5]	$6.7
	Project Rullison	ER	C/A ongoing	1	$0.18[5]	Included in Proj. Rio Blanco
	Rifle Mill (New)	ER/UMTRA	C/A ongoing (ground water)	1	$1.4	$20.3
	Rifle Mill (Old)	ER/UMTRA	C/A ongoing (ground water)	1	included in New Rifle	included in New Rifle
	Rocky Flats Environmental Technology Site	ER (including D&D) on NPL	C/A ongoing	16	$484.3	$5,874.2
	Union Carbide (Slick Rock)	ER/UMTRA	C/A ongoing (ground water)	2	included in Old North Continent	included in Old North Continent
FL	Pinellas Plant	ER	IA in progress RA pending	12	$4.0	$44.8
HI	Kauai Test Facility	ER	RA pending	Included in data for Sandia National Laboratory-Albuquerque		
IA	Ames Laboratory	ER	C/A, S&M ongoing	3	$0.19	$2.2

Exhibit 7-2: DOE Locations Where Characterization and Assessment Are Ongoing (continued) [1]

State	Installation/Site	Program[2]	Status[3]	No. of Operable Units[3,4]	Estimated Budget FY 1997 (millions)[3]	Estimated Life-Cycle Cost (millions)[3]
ID	Argonne National Laboratory-West	ER (including D&D)	C/A ongoing IA in progress	6	$2.6	$21
	Idaho National Engineering Laboratory	ER (including D&D) on NPL	C/A, D&D, RA ongoing	106	$112.8	$3,049.1
IL	Argonne National Laboratory-East	ER (including D&D)	C/A, D&D ongoing	22	$8.5	$169.6
	Madison	ER/FUSRAP	Not initiated	1	$0.0	$2.5
	Site A/Plot M, Palos Forest Preserve	ER	C/A ongoing	1	$0.17	$6
KY	Paducah Gaseous Diffusion Plant	ER (including D&D) on NPL	C/A, S&M ongoing	19	$39.7	$4,830.7
MA	Chapman Valve	ER/FUSRAP	Not initiated	1	$0	NA
	Shpack Landfill[8]	ER/FUSRAP on NPL	C/A ongoing	1	$0.04	$0.4
MD	W.R. Grace & Company	ER/FUSRAP	RA pending	1	$0.0	$21.5
MO	Kansas City Plant	ER (including D&D)	C/A, RA ongoing	13	$3.5	$28.1
	St. Louis Airport Site	ER/FUSRAP on NPL	RA pending	1	$10.4[9]	$243.8[10]
	Weldon Spring Site	ER (including D&D) on NPL	C/A, RA ongoing	8	$66	$447.9

Exhibit 7-2: DOE Locations Where Characterization and Assessment Are Ongoing (continued) [1]

State	Installation/Site	Program[2]	Status[3]	No. of Operable Units[3,4]	Estimated Budget FY 1997 (millions)[3]	Estimated Life-Cycle Cost (millions)[3]
NJ	DuPont & Company	ER/FUSRAP	RA pending	1	$0.003	$7.6
	Maywood Chemical Works	ER/FUSRAP on NPL	RA pending	1	$10.9	$254.9
	New Brunswick Site	ER/FUSRAP	RA pending S&M ongoing	1	$0.5	$5.8
	Princeton Plasma Physics Laboratory	ER	C/A ongoing	2	$0.5	$59
	Wayne	ER/FUSRAP on NPL	RA pending	1	$6.1	$98.9
NM	Ambrosia Lake	ER/UMTRA	C/A ongoing (ground water)	1	$0.17	$1.2
	Gasbuggy Site	ER	C/A ongoing	1	$0.79	$14.5[11]
	Gnome-Coach Site	ER	C/A ongoing	1	$0.36	Include in Gassbuggy site
	Los Alamos National Laboratory	ER (including D&D)	C/A, D&D, RA ongoing	6	$48.5	$623.7
	Sandia National Laboratory	ER (including D&D)	C/A ongoing	18	$17.8	$231.2
	Shiprock Site	ER/UMTRA	C/A ongoing (ground water)	1	$1.7	$7.6
NV	Central Nevada Test Site	ER	C/A ongoing	6[10]	$0	$8.2[11]
	Nevada Test Site	ER (including D&D)	C/A ongoing	31	$51	$2,235.8[13]
	Shoal Test Site	ER	C/A ongoing	[10]	$0	[11]
	Tonopah Test Range	ER	C/A ongoing	[10]	[12]	[12]

Exhibit 7-2: DOE Locations Where Characterization and Assessment Are Ongoing (continued) 1

State	Installation/Site	Program[2]	Status[3]	No. of Operable Units3,4	Estimated Budget FY 1997 (millions)[3]	Estimated Life-Cycle Cost (millions)[3]
NY	Ashland Oil Co.#1	ER/FUSRAP	RA pending	1	$0	$21.3
	Ashland Oil Co.#2	ER/FUSRAP	RA pending	1	$0	$8
	Bliss & Laughlin Steel	ER/FUSRAP	RA pending	1	$0.49	$1
	Brookhaven National Laboratory	ER (including) D&D on NPL	C/A, S&M ongoing	9	$15.1	$332.4
	Linde Air Products	ER/FUSRAP	RA pending	1	$0	$28.2
	Seaway Industrial Park	ER/FUSRAP	RA pending	1	$0	$28.3
	Separation Process Research Unit	ER (including D&D)	Not initiated	1	$0.0	$144.9
OH	B and T Metals	ER/FUSRAP	Not initiated	1	$0.13	$3
	Fernald Site	ER on NPL	RA, D&D ongoing	11	$260.3	$2.523.7
	Luckey	ER/FUSRAP	Not initiated	1	$2.9	$62.7
	Mound Plant	ER (including D&D) on NPL	C/A ongoing	14	$50	$892.9
	Painesville	ER/FUSRAP	Not initiated	1	$4.8	$88
	Portsmouth Gaseous Diffusion Plant	ER (including D&D)	C/A, RA, D&D ongoing	30	$45.9	$3,959.7
	RMI Site	ER (including D&D)	C/A ongoing	3	$18	$131.3
OR	Lakeview Site	ER/UMTRA	C/A ongoing (ground water)	1	$0.03	$5.8

Exhibit 7-2: DOE Locations Where Characterization and Assessment are Ongoing[1]

State	Installation/Site	Program[2]	Status[3]	No. of Operable Units[3,4]	Estimated Budget FY 1997 (millions)[3]	Estimated Life-Cycle Cost (millions)[3]
PA	Canonsburg Site	ER/UMTRA	C/A ongoing (ground water)	1	$0.28	$2.5
PR	Center for Environmental Research	ER	RA pending			
SC	Savannah River Site	ER (including D&D) on NPL	C/A, RA ongoing	92	$111.7	$12,687
TN	Oak Ridge K-25 Site	ER (including D&D) on NPL	C/A, S&M ongoing	33	$64.8	$4,465.6
	Oak Ridge National Laboratory	ER (including D&D) on NPL	C/A ongoing	48	$46.4	$4,872.6
	Oak Ridge Reservation Offsite	ER	C/A ongoing	9	$11.8	$267.1
	Oak Ridge Y-12 Plant	ER (including D&D) on NPL	C/A ongoing	31	$23.2	$1,742.9
TX	Falls City Site	ER/UMTRA	C/A ongoing (ground water)	1	$0.4	$5.5
	Pantex Plant	ER on NPL	C/A ongoing	16	$9.1	$51.6
UT	Green River Site	ER/UMTRA	C/A ongoing (ground water)	1	$0.02	$8.2
	Mexican Hat Site	ER/UMTRA	C/A ongoing (ground water)	1	$0.5	$3.4
	alt Lake City Site	ER/UMTRA	C/A ongoing (ground water)	1	$0.5	$7.3

Exhibit 7-2: DOE Locations Where Characterization and Assessment Are Ongoing (continued) [1]

State	Installation/Site	Program[2]	Status[3]	No. of Operable Units[3,4]	Estimated Budget FY 1997 (millions)[3]	Estimated Life-Cycle Cost (millions)[3]
WA	Hanford Site	ER (including D&D) on NPL (4 sites)	C/A, D&D, RA, S/M ongoing	78	$138.8	$8,349.2
WY	Riverton Site	ER/UMTRA	C/A ongoing (ground water)	1	$0.4	$9.9
	Spook Site	ER/UMTRA	C/A ongoing (ground water)	1	$0.3	$1

ER Environmental Restoration
UMTRA Uranium Mill Tailing Remedial Action
C/A Characterization and Assessment
D&D Decontamination and Decommissioning
FUSRAP Formerly Utilized Sites Remedial Action Program
RA Remedial Action
NPL National Priorities List
IA Interim Action
S & M Surveillance and Monitoring

Notes:

1 This table includes installations and other locations where characterization and assessment are in progress or have yet to be initiated for some or all operable units. Some installations and other locations included here also may appear in Exhibit A-1, because they have both ongoing and completed remedial actions and characterization and assessment activities.

2 U.S. Department of Energy, "The 1996 Baseline Environmental Report," DOE/EM-0290, June 1996.

3 U.S. Department of Energy, "The 1996 Baseline Environmental Report," DOE/EM-0290, June 1996; data as of June 1996 from DOE's "1996 Baseline Environmental Report" Database and other internal DOE databases provided by the Systems Management Division, Office of Program Integration, Office of Environmental Restoration and interviews with selected site operations staff at DOE Headquarters, June 1995. Actual Congressional appropriations for FY 1997 may differ from the amounts printed here. Data on operable units and life-cycle costs come from several different sources, which are continuously being revised by DOE staff as conditions at specific installations and other locations change and as new sites are identified. In addition, these data were extracted from these sources at different times. Therefore, although these data provide an indication of the approximate level of effort needed at a given location, their sum may not accurately reflect the program total.

Exhibit 7-2: DOE Locations Where Characterization and Assessment Are Ongoing (continued) [1]

Notes (continued):

[4] "Operable unit" consists of one or more "sites" (individual areas of contamination). DOE aggregates sites with similar characteristics or sources into operable units to facilitate remedy selection and operations for all its remediation projects, whether they are conducted under CERCLA, RCRA, or other authorities.

[5] Work at Amchitka Island (AK), Project Rio Blanco and Project Rulison (CO), Salmon Test Site (MS), Project Gassbuggy and Gnome-Coach Site (NM), and the Central Nevada, Shoal, and Tonopah Test Sites (NV) is managed by and funded through DOE's Nevada Operations Office.

[6] DOE does not manage the cleanup work at this site. The agency is providing support to the Potentially Responsible Party.

[7] Total estimated FY97 budget for all Missouri FUSRAP sites is $10.4 million.

[8] Total estimated life-cycle cost for all Missouri FUSRAP sites is $243.8 million. Site-by-site estimates are not available.

[9] Includes Gassbuggy and Gnome-Coach sites.

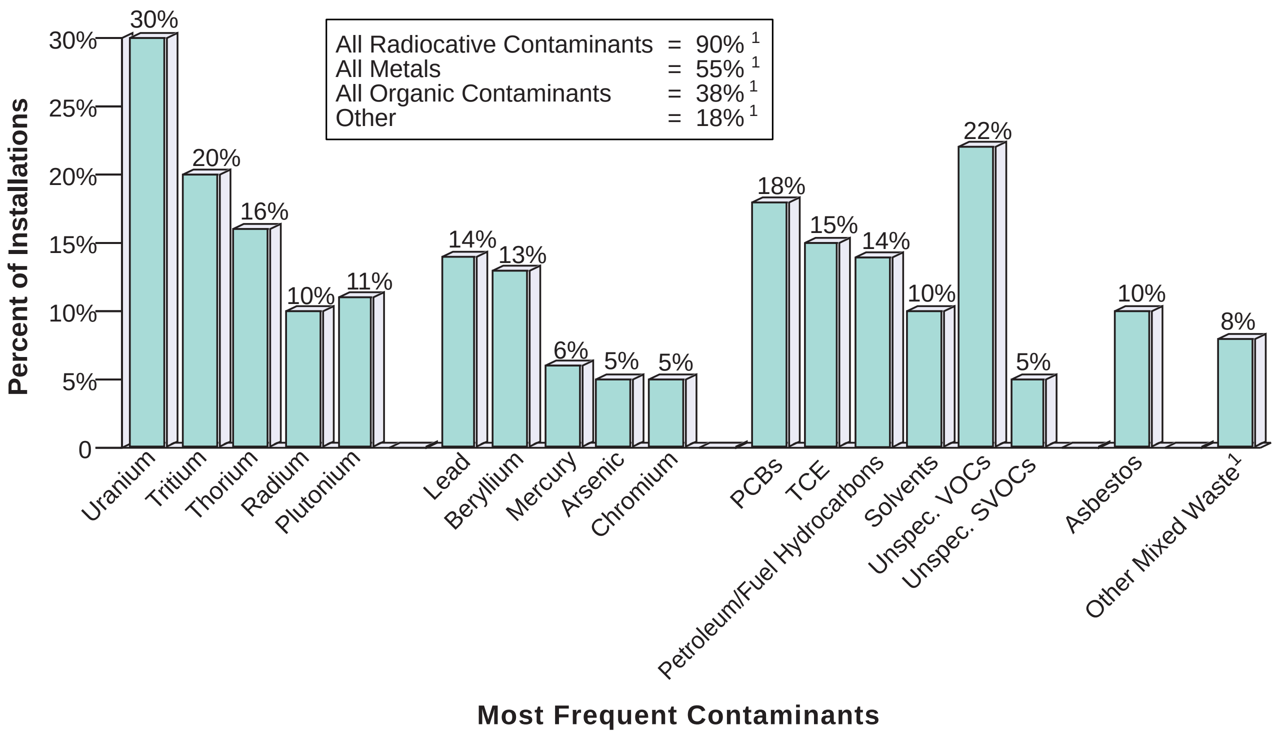
[10] A total of six operable unit equivalents has been identified for the Central Nevada, Shoal, and Tonopah Test Sites.

[11] Includes estimated life-cycle cost for Central Nevada and Shoal.

[12] Included in Nevada Test Site.

[13] Included in estimated life-cycle cost for Nevada test sites and Tonopah.

Exhibit 7-3: Percent of DOE Installations and Other Locations Containing Specific Contaminants



Notes: [1] Includes all contaminants in a group; not only those indicated by the bars. A site may contain more than one contaminant. Other mixed waste indicates installations and other locations with mixed waste for which specific contaminants have not been delineated.

Sources: U.S. Department of Energy, *Estimating the Cold War Mortgage: The 1995 Baseline Environmental Report*, DOE/EM-2032, March 1995; DOE/EM-40 Contaminated Media/Waste Database as of March 3, 1995; and UMTRA Project Office, "Draft Programmatic Environmental Impact Statement for the Uranium Mill Tailings Remedial Action Ground Water Project," DOE/EIS-0198, April 1995.

DOE installations and other locations contain contaminated soil and sediment, groundwater, and rubble and debris. Estimates of the volumes of these media that still need to be remediated at each installation are included in Appendix Exhibit D-2. Since characterization and assessment are ongoing at most of these installations, these estimates may change. Individual estimates of the volume of groundwater to be remediated are not available for the 23 UMTRA project locations included in this Exhibit, but DOE estimates that a total of about 4.7 billion gallons of groundwater are contaminated at these UMTRA locations.[8]

7.4 Estimated Cleanup Costs

DOE estimates that it will take about $63 billion (28 percent of the estimated $227 billion cost of all environmental management activities) over a 75-year period to substantially complete environmental restoration—including cleanup of contaminated soil and groundwater, decontamination and decommissioning of nuclear reactors and chemical processing buildings, and exhumation of buried waste—at its installations and other locations. These expenditures will not be evenly distributed over the 75-year life of the agency's environmental cleanup program. After peaking at about $2 billion in 2000, they will decline gradually until the program is substantially complete in 2070 (Exhibit 7-4). The agency expects to expend about $12 billion (five percent of the $227 billion total) for technology development to support cleanup and other DOE environmental management activities over the life of the program. These estimates are the result of a comprehensive analysis of the status and potential cost of cleaning up contamination accumulated as a result of past activities, as well as the wastes to be generated from ongoing national security operations and from the cleanup efforts themselves.[2]

Because of the wide variance in size and complexity of installations and other locations to be remediated, life-cycle-cost estimates vary among installations as well. For example, cleanup of the 82-acre Geothermal Test Facility in Imperial Valley, California, is expected to cost a total of about $5.1 million, while cleanup of the 11-square-mile Rocky Flats Plant northwest of Denver, Colorado, is expected to require about $5.8 billion. The methodology in the "Baseline" report for calculating the cost of accomplishing DOE's environmental cleanup responsibilities involved the use of a "base-case" scenario, the agency's best estimate of the environmental management activities to be undertaken at each site, which was developed using data and assumptions supplied by DOE field offices. Life-cycle cost estimates were generated for each of about 40 percent of the agency's major installations and other locations. Aggregate state-by-state estimates were generated for the 70 sites managed under the FUSRAP and UMTRA programs and for nine off-site locations managed by the Nevada Operations Office.[2] These estimates, as well as estimates for FY 1997 expenditures, are shown in Exhibit 7-2 and Appendix Exhibit D-3.

These "base-case" estimates provide the most reliable information to date on the value of the DOE market. However, the actual value may be higher or lower for a number of reasons. First, as with any such analysis, the DOE estimates were based on a set of assumptions. For example:

- Activity will significantly increase between 1995 and 2000 and will shift from characterization to include more active remediation at DOE contaminated sites. In addition, major facilities will be deactivated.

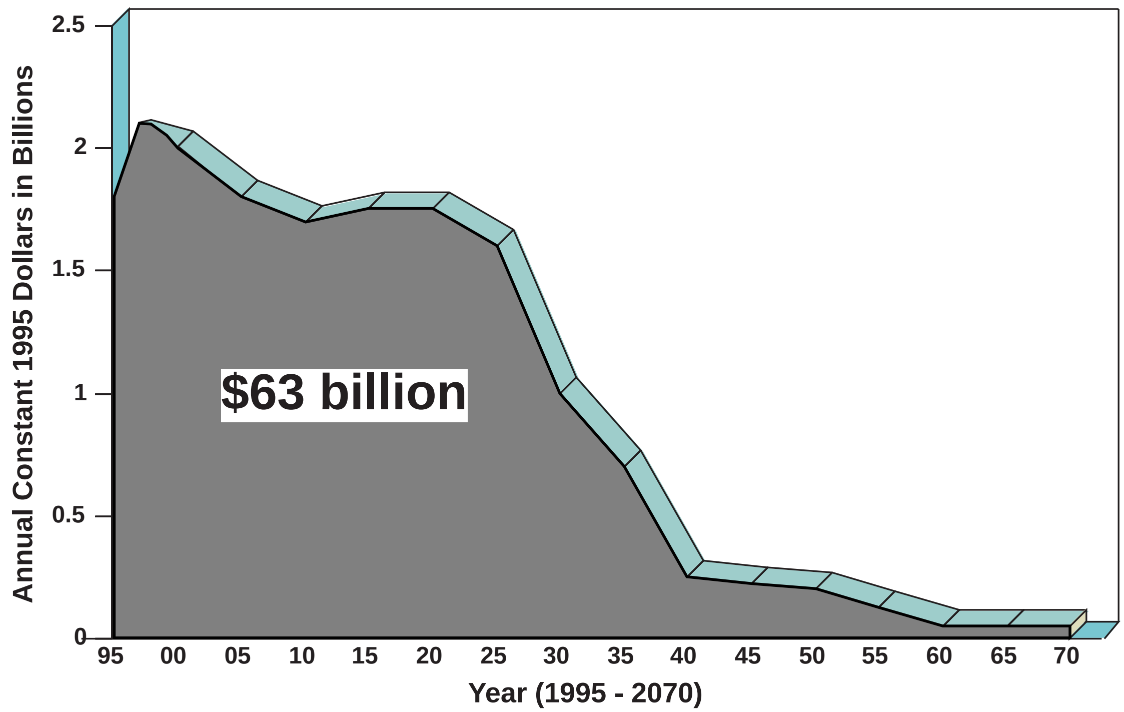
- Milestones in existing compliance agreements will be completed. Compliance agreements affecting DOE cleanups under CERCLA and RCRA at 17 DOE installations are in place (Appendix Exhibit D-4). DOE currently is committed to meeting more than 70 compliance milestones, most of which do not extend beyond 2000. The only funding increases assumed beyond 2000 were those dictated by existing compliance agreements.

- Most remediations will use existing technologies. Assumptions about the nature and extent of contamination were developed at the field level and, therefore, varied from installation to installation. Based on these individual assumptions, field personnel selected one of two types of assumed remedial actions: strategies to contain contamination or strategies to eliminate contamination. Since radionuclides and other contaminants such as heavy metals cannot be destroyed, containment was the option usually assumed for contaminated soil and buried waste. Measures to prevent further contaminant migration and protect off-site populations—removing or capping the source to prevent leaching, using slurry walls and other technologies to contain contamination in groundwater, natural attenuation, or pump-and-treat—were the options assumed for groundwater.[2]

Second, the estimates could not include projected costs for cleanup where no feasible cleanup technology exists—such as nuclear explosion sites and much of the groundwater contamination the agency is responsible for addressing.

Third, some of the same factors that influence the demand for DOE installation remediation (see Section 7.2) will affect the actual costs of cleanup activities. These include the relatively limited characterization of the problems at many sites; uncertainty about what level of residual contamination after cleanup will be acceptable to regulators and the public; the lack of definitive policies on future use of land and facilities; uncertainty about the consistent availability of funding; and the inherent uncertainty in a program that is expected to last at least 75 years.[2] For example, the ultimate cost of groundwater cleanup at DOE's UMTRA sites is uncertain, because the program still is in its early planning stages. According to a December 1995 report by the General Accounting Office, its final scope and cost will depend largely on the methods chosen to conduct the cleanups, which cannot be determined until site characterization studies and environmental assessments have been completed, and the capability and willingness of

Exhibit 7-4: Life Cycle Cost Profile for DOE's Environmental Restoration Program



Source: U.S. Department of Energy, *The 1996 Baseline Environmental Management Report,* DOE/EM-0290, June 1996.

the affected states, which are required to contribute 10 percent of the cost of remedial actions under the UMTRA program, to pay their share.[10]

In preparing the "Baseline" report, DOE developed hypothetical cases to examine the potential impact of land use, residual contamination, funding/scheduling, and innovative technology issues on the agency's overall environmental management cost estimate. These "alternative-case" analyses primarily were prepared to assist in future policy-making efforts and were not factored into the baseline $63 billion life cycle cost estimate for environmental restoration and $227 billion for all of DOE environmental management. The agency used a standardized modeling approach for the analyses, rather than relying on the field estimates and assumptions that were the foundation for the "base-case" estimates. Major conclusions regarding the overall DOE program included the following:

- **Projected future land use will dramatically affect costs.** The most restrictive hypothetical land-use scenario would cost about 90 percent more than the least restrictive use. These estimates are for all of environmental management. Separate figures were not published specifically for site restoration. In this comparison, the most restrictive land use is "off-limits to human activity," and the cost estimate was based exclusively on containing contamination by capping contaminated soil and buried wastes, controlling the spread of groundwater contamination by hydraulic controls and barriers, and entombing contaminated facilities in place. In this comparison, the least restrictive hypothetical scenario is essentially unrestricted use, which would be achieved by implementing aggressive removal strategies at operable units for which technologies are available. In cases where current technologies are unavailable or where sites are being used for active disposal, the scenario was based on using containment and restricted land use only.

- **Reducing DOE's annual environmental cleanup budget and extending the program's schedule would significantly increase life-cycle costs.** If the DOE annual budget were restricted to 65 percent of the baseline cost estimate, total program costs would be increased by 30 percent. Most of this cost would be due to increased pretreatment storage, increased storage and maintenance for plutonium storage buildings and chemical separation facilities, and support costs.[2]

- **A hypothetical program involving only minimal action to stabilize sites up to 2070 would require 44 percent less funding than the base case, from 1997 through 2070.** However, costs after 2070 would be higher than now projected. This hypothetical program would include treatment and disposal of all high-level waste and spent nuclear fuel; stabilization and surveillance and maintenance of surplus facilities; and safe storage of all low-level, low-level mixed, and transuranic wastes. No environmental restoration, decontamination and decommissioning, or treatment and disposal of low-level, low-level mixed, and transuranic wastes would be carried out under this scenario.[2]

- **Development of new technologies will reduce certain cleanup costs and make some currently infeasible cleanups possible.** For the 1995 annual report,[3] DOE selected a number of specific technologies scheduled to be available by 2000 for this analysis. These included electrokinetics, innovative soil washing (specifically used for removal of normally immobile metal ions, including radioactive contaminants like cesium), and *in situ* vitrification for soils; recirculating wells, microbial filters, *in situ* bioremediation, dynamic underground stripping, and biosorption of uranium for groundwater; plasma hearth technology for mixed low-level waste treatment; as well as technologies potentially applicable for facility decontamination, buried waste, characterization, and high-level waste. The analysis showed that use of these technologies at selected operable units could save as much as $9 billion when applied to the 1995 "base-case" scenario and as much as $80 billion when applied to the least restrictive hypothetical land-use scenario. This type of analysis was not included in the 1996 report, but some of these potential savings were incorporated into the 1996 baseline cost estimates.[2][3]

7.5 Market Entry Considerations

Contractors perform virtually all cleanup and restoration work at DOE installations. DOE issues "requests for proposals" and awards contracts on a competitive basis. DOE awards remedial action contracts on an installation-by-installation basis. DOE Operations Offices, each of which is responsible for one or more installations, manage the contracts. Operations Offices are listed in Appendix E. Contracts related to the FUSRAP and UMTRA programs, both of which include sites in many states, are managed through the Oak Ridge and Albuquerque Operations Offices, respectively.

A list of DOE's current management and operations (M&O) contractors is presented in Appendix E. Depending on the installation, these contractors may be responsible for management tasks, actual cleanup work, waste management duties, or various combinations. For example, under the Environmental Restoration Management Contract (ERMC) awarded at Fernald and the Environmental Restoration Contract (ERC) awarded at Hanford, contractors are responsible for day-to-day project management; have the option of performing the remedial investigation / feasibility study portions of the cleanup process; and, after a ROD is issued for a given operable unit, will be responsible for subcontracting the remaining work to companies with specialized expertise and technology.

DOE has begun to implement a number of contract reforms that emphasize performance-based approaches (focusing on desired endpoints instead of level of effort) and risk sharing (contractors assuming more of the financial risk over time) and provide incentives for M&O contractors to reduce cost, increase safety, and identify tasks that should be undertaken by qualified subcontractors. The first two integrated management contracts awarded under the new system have been multi-year efforts for management and cleanup of Idaho National

Engineering Laboratory (INEL), awarded in August 1994, and Rocky Flats, awarded in April 1995.[11] These measures may influence not only the overall value of the DOE market but also the amount of work available to subcontractors, because of its emphasis on increasing the use of subcontractors for some specialized functions.

7.6 Technologies Used and Research, Development, and Demonstrations

Information on the innovative technologies being used at DOE installations is too limited to predict future technology use. However, insight into potential applications may be obtained from the following examples of applications at Superfund cleanups at DOE installations: *in situ* bioremediation is currently operational at DOE's Savannah River installation; soil vapor extraction (SVE) is being installed in an Interim Action at Rocky Flats' Operable Unit 2; a SVE system is in the design phase for use at Lawrence Livermore National Laboratory; and chemical leaching is being used with incineration at the Idaho National Engineering Laboratory's Pit 9.[12]

DOE recognizes that much of the cleanup and environmental restoration at its installations cannot be accomplished without new technological solutions. Thus, DOE cleanups provide an opportunity for developers of innovative technologies. Early in 1995, DOE reorganized its technology-related research and development activities to target five of the most important remediation and waste management problems within the DOE complex. In addition, the reorganization established five areas for the development of cross-cutting technologies.

The agency's new approach emphasizes: 1) teaming with technology customers within the Office of Environmental Management and industry to identify, develop, and implement needed technologies; 2) more effectively focusing the available resources in DOE's national laboratories; 3) involving academia and other research organizations in basic research programs; 4) expanding the participation of regulators and stakeholders in technology development; and 5) enhancing the agency's ability to implement the results of technology development efforts.

Focus Areas

Four "Focus Areas" have been targeted on the basis of the risk they present, their prevalence at DOE sites, or the lack of technology to meet environmental requirements and regulations. Each of the "Focus Areas" has identified specific categories of technologies on which research and development work is needed. These are:

- Subsurface Contaminants Focus Area — Includes containment and treatment of soil, water, vegetation, and other wastes. Includes aquifer properties characterization, on-line remediation process controls, and subsurface access and exploration; reactive barriers, deep subsurface barriers, temporary barriers, and barrier emplacement; and *in situ* physical, chemical, and biological treatment. This focus area plans to concentrate over the next three years on technology development to expedite the characterization of contaminant plumes and ways to control sources and migration, and to facilitate implementation of emerging remediation technologies. Over the next six years, the goal of development work in this Area is to achieve breakthroughs on problems for which remediation technologies do not exist, especially dense non-aqueous phase liquids (DNAPLs), heavy metals, and radionuclide contamination in aquifers and overlying soils.

  This focus area also addresses landfill stabilization, including the following activities: site and waste characterization, full-scale and "hot spot" retrieval, treatment, subsurface caps and barriers, and stabilization. This Focus Area is concentrating on developing, demonstrating, and implementing technologies to remediate about three million cubic meters of buried waste in landfills located predominantly at Hanford, Savannah River, Idaho National Engineering Laboratory, Los Alamos National Laboratory, Oak Ridge Reservation, the Nevada Test Site, and Rocky Flats.[13]

- Mixed Waste Characterization, Treatment, and Disposal Focus Area — characterization, thermal treatment, non-thermal treatment, and effluent monitoring and control. This Focus Area plans to conduct a minimum of three pilot-scale demonstrations of mixed waste treatment systems, using actual mixed waste, by 1997.[14]

- Radioactive Tank Waste Remediation Focus Area — characterization, retrieval and conveyance, separation and pre-treatment, low-level waste treatment and disposal, and immobilization. Development work in this focus area has concentrated on four DOE installations—Hanford, Idaho National Engineering Laboratory, Oak Ridge Reservation, and the Savannah River Site—where most of the DOE inventory of underground storage tanks containing radioactive waste is located.[15]

- Facility Deactivation, Decontamination and Material Disposal Focus Area — deactivation, decontamination, dismantling, and material disposal. This focus area currently is in the process of selecting an installation for a full-scale demonstration of facility decommissioning technology with an emphasis on the recycling of contaminated building materials for reuse within the DOE complex.[6]

A list of the points of contact for each of the agency's five technology development focus areas is included in Appendix E.

In preparing the alternative-case analyses for its "Baseline" report, DOE selected 15 new technologies, scheduled to be available by 2000, to analyze the potential cost savings the agency could realize through the use of innovative technologies in its environmental restoration efforts. They provide developers and vendors with specific examples of the types of technologies the agency expects to need in the next few years. A list of these technologies is presented in Exhibit 7-5.

Cross-Cutting Technologies

Cross-cutting technologies are defined as those which overlap the boundaries of "Focus Areas." Technologies developed in these areas will be used in "Focus Area" testing and evaluations programs wherever they are applicable. These areas are: Characterization, Monitoring, and Sensor Technology; Efficient Separations and Processing; Robotics; and Industry Programs.

The Industry Programs Area has set aside funding to foster research and development partnerships with the private sector for introducing innovative technologies into the technology development programs managed by the agency's Office of Science and Technology. Support in this area will concentrate on two types of technologies: technologies that show promise for addressing specific DOE problems and require proof-of-principle experimentation, and technologies proven in other fields that require critical path experimentation to demonstrate feasibility for adaptation to specific DOE problems.[6]

The "Focus Area" concept builds on the work carried out under DOE's Integrated Programs and Integrated Demonstrations, through which the agency managed the research, development, demonstration, testing, and evaluation of technologies for application at DOE installations and other locations.

Private Sector Involvement

DOE uses several mechanisms to invite the private sector to participate in its technology research and development programs. These include Cooperative Research and Development Agreements (CRADAs), technology development contracts issued under Program Research and Development Announcements (PRDAs), Research Opportunity Announcements (ROAs), and the Small Business Technology Integration Program.

DOE uses CRADAs as an incentive for collaborative research and development. CRADAs are agreements between a specific DOE laboratory and a non-federal source to conduct mutually beneficial research and development that is consistent with the laboratory's mission. DOE has issued 62 CRADAs to date to support its environmental programs.

Technology development contracts under PRDAs and ROAs, which support technology development to meet EM program needs, are managed by DOE's Energy Technology Center (Morgantown, West Virginia). DOE issued its first

Exhibit 7-5: Examples of Innovative Technologies Useful to DOE

Technology	Analysis
Soil remediation	**Electrokinetics** — Mobilizes contaminant ions in the subsurface by the application of a direct electrical current between buried electrodes. Contaminants then are collected and removed from the vicinity of the electrodes for disposal or further processing. A pilot-scale demonstration of this technology for the remediation of chromium contamination is underway at Sandia National Laboratory. **Innovative Soil Washing** — *Ex-situ* treatment metal contaminated soils by the adaptation of standard mining technologies. Particulate and absorbed/adsorbed contaminants can be removed allowing the "cleaned" soil to be replaced. The collected metals then are disposed of or reprocessed for recycle/reuse. Several such technologies have been demonstrated by the Mackay School of Mines at the University of Nevada at bench and pilot scale. Sites for full-scale demonstration are being investigated. ***In Situ* Vitrification (ISV)** — *In situ* heating of soil to above its melting temperature. Upon cooling, the molten soil mass creates a glass-like monolith that essentially immobilizes contaminants. The glass is resistant to leaching and weathering and can be left in place; no further treatment is necessary. Field-scale demonstrations of this technology have been conducted at Hanford and Oak Ridge sites. A large-scale demonstration also has been performed at Hanford.
Groundwater	**Dynamic Underground Stripping** — Surrounding of an underground contaminant plume with injection wells and electrical heating of clay-rich soil layers while sandy layers are flooded with steam. This combination volatilizes contaminants (NAPLs and other inorganic solvents) which are carried by the steam to a central extraction well. The steam is condensed, extracted, and treated above ground; the water is reinjected, and the contaminants are removed for disposal. A full-scale demonstration was conducted at Lawrence Livermore National Laboratory in 1994. The technology currently is available for licensing. ***In Situ* Bioremediation** — Stimulation of indigenous microbes or introduction of foreign microbes in the contaminated region. The microbes stimulate the remediation of the area through the metabolism of the contaminant or by causing reactions to occur which release the contaminants from the soil, allowing a conventional removal action (such as pump-and-treat) to remediate the site more efficiently. A field demonstration was undertaken at Hanford in 1995; results are pending. **Biosorption of Uranium** — Remediation of uranium-contaminated ground and surface water using biosorbents (sorptive biomass or biological material) immobilized in permeable beads that, in turn, are contained within a flow-through bioreactor system. The technology is a partnership between Oak Ridge National Laboratory and Ogden Environmental and Energy Services, Inc. Bench-scale testing has been completed. **Recirculating wells** — Use of specially designed wells to pump water or soil air through a screened interval and to transfer it back into the aquifer through a separate interval. Treatment occurs below ground within the well casing, thereby reducing utility and maintenance expense and regulatory costs. Recirculation also provides better control of groundwater flow through hydrodynamically connected wells. Demonstration is underway at the Portsmouth Gaseous Diffusion Plant on a 0.5-mile plume that contains high levels of TCE and Tc-99. **Microbial filters** — Placement of a permeable wall of TCE-degrading microorganisms in the subsurface to intercept a contaminant plume. Contaminants are degraded by microorganisms in the biofilter as the plume passively flows through it with the natural hydraulic gradient. The filter can be formed by direct injection of microorganisms into the subsurface to form a wall or by injecting them into an emplaced sand trench. Field-scale tests of this technology have been conducted at sites at Kennedy Space Center in Florida and Chico Municipal Airport, California.

Exhibit 7-5: Examples of Innovative Technologies Useful to DOE (continued)

Technology	Analysis
Facilities	**Gas Phase Decontamination** — Treatment of gaseous diffusion plant equipment interiors contaminated with solid uranium deposits with chlorine trifluoride gas. The gas is introduced in the process equipment and volatilizes the uranium deposits into a product gas mixture, which is removed, separated, and recovered.
Buried waste	**Cooperative Telerobotic Retrieval** — Selective and remote retrieval of buried radioactive and hazardous wastes to reduce exposure risks to remediation workers and the environment and costs associated with full-pit retrieval. The system consists of telerobotic manipulators, mounted on a gantry crane, that are capable of performing a variety of tasks—for example, retrieving intact containers and deploying dig face characterization sensors and ancillary tools (such as a camera, a soil vacuum, dust suppression sprays, and cutting equipment). A full-scale demonstration is being performed at Idaho National Engineering Laboratory. **Automated Waste Conveyance System** — Remote and safe transportation of retrieved radioactive and mixed wastes from the dig face to a waste processing and packaging area to reduce exposure risks to remediation workers and the environment. After retrieved waste is loaded into the container of the system, the container lid is remotely closed and locked to contain dust generated during conveyance. A full-scale demonstration was performed at Idaho National Engineering Laboratory in FY 1995.
Mixed low-level waste treatment	**Plasma Hearth System** — Thermal treatment characterized by high-efficiency destruction of organics, encapsulation of heavy metals and radionuclides in a vitrified final waste matrix, maximum reduction of waste volume, low off-gas rates, and the capability of processing many waste types in a single step process without the need for expensive pre-treatment.
Characterization	**Expedited Site Characterization** — Process with a regulator-accepted work plan that permits a multi-disciplinary team of experts concurrently to collect and integrate field data to develop and evaluate a site model. Sampling locations are determined daily in the field, based on evolving site model knowledge and results, yielding a faster, less expensive, and superior model.
High-level waste	**Efficient Separations** — Chemical processes and chemical reactions, which enhance separations or eliminate a separation step by destroying a contaminant, for use in treating and immobilizing a broad range of radioactive wastes. In some cases, separation technologies do not exist; in others, improvements are needed to reduce costs, reduce secondary waste volumes, and improve waste form quality. **Robotic Systems** — Remotely operated equipment for retrieving and handling high-level waste stored in underground tanks.

Source: U.S. Department of Energy, "Estimating the Cold War Mortgage: The 1995 Baseline Environmental Report," DOE/EM-0230, March 1995.

PRDA in December 1991, for $10 million. This PRDA focused on groundwater and soils technologies and resulted in the award of 21 contracts to the private sector and university technology developers. A second PRDA, of equal value, was issued in 1992. It solicited for novel decontamination and decommissioning technologies and resulted in the award of 18 contracts to private sector technology developers.

Two ROAs also have been issued, soliciting for technologies in the areas of *in situ* remediation; characterization, sensing, and monitoring; efficient separations for radioactive wastes; and robotics. Twenty-seven contracts have been awarded under these ROAs to the private sector. DOE has established a 20-percent set-aside for small firms (500 employees or fewer) for applied research projects funded through ROAs. To date, however, 30 to 50 percent of these contracts have gone to small businesses.[16]

By early 1995 a total of 55 PRDA and ROA contracts had been awarded for a sum of $93.4

million. PRDAs and ROAs are published in the *Federal Register* and their availability is listed in the *Commerce Business Daily*. Information about announcements also is available on the Internet on the Federal Information Exchange, Inc. —FEDIX Home Page (http://web.fie.com/fedix/index.html).

DOE maintains a Web site to connect DOE's site specific needs with private industry capabilities (http://www.ead.anl.gov/techcon/). The web site is part of DOE's overall effort to better match site needs with commercial or emerging capabilities that will enable performance improvement while limiting risk.

DOE's Small Business Technology Integration program identifies funding to support innovative technology development by small businesses. The Program also sponsors workshops as a forum for face-to-face meetings between small business operators and DOE staff who can provide information on specific business opportunities. In addition, a small business coordinator is available at DOE Headquarters to provide one-on-one counseling for small, disadvantaged, or minority businesses and provide access to procurement offices at DOE installations. For additional information about DOE's small-business-oriented programs, contact the U.S. Department of Energy, Office of Technology Development/Technology Exchange Division (EM-521), Washington, DC 20585.[17]

DOE also is one of 11 agencies involved in the Small Business Innovation Research (SBIR) Program, administered by the Small Business Administration (SBA). The three-phase program is designed to facilitate technology transfer by identifying funding to support innovative technology development by small businesses. Proposals for work under the program are invited through an annual solicitation announcement. Grants or contracts awarded under phase one of the program provide $60,000 to $100,000 for up to six months to conduct feasibility studies for research ideas that appear to have commercial potential. Phase-two funding of up to $750,000 provides for 12 to 24 months of additional research, development, demonstration, and evaluation of the technology. Phase three of the project involves commercializing the technology and using it for full-scale remediation. About two percent of DOE's extramural research budget for FY 1996 is expected to be available to small businesses under this program. Notices of all federal SBIR opportunities are published by the SBA on its SBA Bulletin Board. The bulletin board can be accessed, by modem, 800-697-4636). SBA Bulletin Board technical support is available by addressing specific DOE problems and require proof-of-principle experimentation, and technologies proven in other fields that require critical path calling 202-205-6400. The SBA Bulletin Board also is available via Telnet at sbaonline.sba.gov.[18]

Developers and vendors of innovative technologies interested in more information about DOE's technology development efforts may contact the DOE's Center for Environmental Management Information (800-736-3282).

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